L60-44

SCIENCE, TECHNOLOGY, AND NATIONAL SECURITY

Mr. J. Carlton Ward, Jr.

NOTICE

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Reviewed by: Captain W. P. Schoeni, USN

Date: 22 October 1959

INDUSTRIAL COLLEGE OF THE ARMED FORCES

WASHINGTON, D. C.

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GENERAL HOUSEMAN: We are going to start the science and security portion of our general lecture series of talks this morning.

This is a knowable audience and it is not necessary for me to bring to your attention the importance of science and technology as it applies to the development of this country from its inception, and the importance of science and technology today.

The subject of today's talk is "Science, Technology, and National Security." Our speaker, Mr. J. Carlton Ward, has been steeped in science and technology during almost his entire adult life. And, to show what we think of Mr. Ward, he's been here intermittently since 1946. He's been intimately connected with the College during that long period of time. He is President of Vitro Corporation and Chairman of the Board of Advisors of this College.

Mr. Ward.

MR. WARD: General Houseman, Gentlemen: Yesterday I was at Aberdeen and had a very interesting day in seeing what the Army was displaying in its new weaponry. I had this assignment for today, and because of the kind of life we lead in industry, or least our kind of industry, I was going to prepare for this last night. But the Army did me in and I went to sleep. You're going to have to bear with me. I will try to work out a proper sequence for you, because I'm like the

case that was told to me about the Fertilizer Manufacturers Association. It appears that they were tired of having these important speakers at their annual meeting and they suggested somebody speak to them from their own industry. And so the experiment was tried. When the day came, these gentlemen had indulged very well in the preliminaries before dinner and were feeling no particular pain, had a good dinner, and the air was relaxed. The executive of the association, the professional head, rose and said: "Well, according to the wishes of the members here, we have no outside speaker for this occasion. We have one of our own executives, Mr. So-and-so, Vice President of Such-and-such Company, who is going to speak to us on humus fertilizers. And, believe me, gentlemen, he is full of his subject."

Now, I'm full of the subject all right, but I would like to try to leave you with some conclusions of your own, not of mine. I don't believe that opinions from this rostrum, as important as the rostrum is, should govern your thinking. You are here to determine your own thinking. So I will try to give you some exhibits, some information, I will tell you some of my own conclusions, and at the end I hope that you will come to your own.

Now, this subject I've been assigned--Science, Technology, and National Security--could obviously be an entire year's course and then you wouldn't do justice to it. It further says: "An examination of the role of scientific research and technology as a contribution to national power in the modern age with an analysis of our current position in this

field in relation to other large nations." Now, that's quite an assignment for a lecture period.

I thought perhaps it might be good to start with some examples, and I'm going to take World War I, and the position of Germany in World War I. How is it that a nation of relatively small population in terms of world population, with very limited natural resources--and Germany has very limited natural resources--could threaten the entire world and feel reasonably sure that she could win in the process? Now, it wasn't political power. It wasn't moral power. It wasn't numbers. It was science and technology--the subject of your lecture today.

At that point in world history--and many of you were not old enough, as I was, to at least have some slight acquaintance with the conditions in the world at that time--Germany had discovered, believe it or not, the role of research. It was the leading nation of the world in technology, particularly in chemistry. It had broken the world monopolies of other countries, such as Japan, in the camphor industry, which was necessary in explosives, of Great Britain in indigo, and in many of the basic chemicals of the time which were grown in tropical lands. Rubber is a typical case, which you dealt with in more recent times. Germany had broken these world monopolies by science and technology. And Germany felt that it had in the economy of the nation mastery over larger population groups and nations which were civilized in the sense of political civilization as she. And so it was Algeciras, I believe, where the Germans first showed their power, or their attitude

toward power; and, of course, you know the history of World War I.

You may remember that we fought that war largely with foreign ordnance. You may remember the enormous growth of our aviation industry, from what was really a toy to a very large industry.

Now, we showed something that the rest of the world didn't have. We showed the technology of mass production. This is peculiarly American. It stems out of our historic background as pioneers arriving in a rich country with all sorts of resources, with no inherited traditional civilization, and with a necessity to fashion cities and a country. So we became a nation of doers.

Now, traditionally the older ~~civilizations~~ countries had inherited their lands and the work of countless generations, whereas the pioneers who founded this country had to start from scratch. So our thoughts were production thoughts. And in World War I we demonstrated to the world the power of our production machine.

This carries on through World War II very well, as you recognize; but today our production mass techniques are used even in China. And if you will find photographs of the Chinese automobile factory, you will find one of the finest mechanized automations in the automobile industry.

So this is a phase, gentlemen, that you can't always rely on. There were plenty of military officers, when I was serving in Ordnance in World War I, who took for granted the fact that our country would respond in immeasurable ways to any need that the military placed on it; just give it a little time. You may remember, our allies bought that

time for us. And so America's technology was very high in mass production, but in science it was not.

I do not believe that in the hour we have today I can fully explore with you why I make that statement, and it is partly true today. In your paper here in Washington this morning you will read an astounding article on astronomy and the formation of the universe by Professor Gold, at Cornell, and you will say, "Well, America is well in the front." But Professor Gold was born in Vienna and was an English citizen. He came to this country late in life.

Now, I am using this example, gentlemen, because it's in your press this morning. Much of your most advanced science--Teller in the hydrogen bomb--he came from Hungary. Dr. Hans Baeder, the man who worked out the nuclear cycle of the sun, which lies underneath any hydrogen bomb developments and hydrogen power, also came from Europe. And so your leading American scientists are not all Americans in the sense that they are not the product of our civilization. We have imported them. Thank heavens they have come.

Do not take for granted that we are a leading scientific nation in the sense of fundamental science. You can fully accept the fact that in applied science and in engineering we are a leading nation. This is one of the things I hope to focus your minds on in this day's talk, because as military people it would not be expected that you would fully experience or understand the difference between scientists and engineers, between theoretical scientists and applied scientists, and yet your future

and that of national security depends upon this relationship. Vannevar Bush, in his book after World War II, who understood this problem thoroughly, made the statement that we had used up fifty years of science in five years of war and it behooved us to fill the reservoir.

Now, when you administer procurement, you are niggardly with respect to fundamental science, and you are generous with respect to hardware and the applied basis of both engineering and science.

I don't suppose as a nation that we can change overnight, because as a nation we have given the accolade to the men who produce--the manufacturer, the industrialist, the big banker--people who deal in quantity. This is typically American. This is not true in Europe, where the man of ideas in science is the big man. We call them eggheads, long hairs, absent-minded professors--all terms of semi-humorous derision. These are not European terms.

Now, this is important to you today, because you are in a world race for survival with a nation who does not agree with you on this point. Sputniks, luniks, moon shots are evidence. These are high scientific developments. These are not hardware developments in the pure sense. Yes, they do have a larger rocket boost than we, and that's hardware. But it isn't hardware that can calculate a shot from the back side of the earth, allowing for the earth's rotation, for the drag of the atmosphere, for the motion of the moon, and arrive at a predestined time and spot with precisely the right speed to accomplish a given objective. This is high science indeed. And so, whereas the public may respond

only because it is an accomplishment of a dramatic nature, you should look at it differently. It is a measure of scientific capability.

Now, many Americans are inclined to think that there is something peculiarly western about this type of capability, that it is in a sense a product of western civilization. This is not true. Some of the finest world scientists come from the Orient. Dr. Hadaki Kagawa, of Japan, singlehandedly produced the concept of high-energy particle fission, the meson. He's the author of the meson. He postulated it before anybody had ever heard of it or measured it. Two Chinese have recently exploded the theory of parity--one of the most significant and subtle underlying basic principles in theoretical physics.

There is no corner on scientific capability in any one nation. It is not wise for us to feel any security with respect to our own capabilities in this field.

I attended a three-day colloquium at Harvard here recently in which there were Nobel Prize winners from Europe, distinguished American scientists and educators, senior scientists from the Defense Establishment; and the subject of the colloquiam was, "What are the influences governing creativity?" Now, this was a very penetrating subject, because your future lies in what I think you and I mean as creativity--the creation of new methods, of weapons, weapons systems employment, combat warfare.

Well, with all these brains from Europe and the United States and three days to work in, they never succeeded in defining creativity.

But everyone recognized that they could identify a creative person.

Now, I won't carry you through that three-day discussion except to say that you are dealing with some very subtle things when you are talking about science, technology, and national security. And it doesn't lie in tons of hardware.

Maybe this is the time, then, to discuss one or two other examples. We have cited World War I and Germany. I could just as well have cited World War II and Germany, because we in United Aircraft, where I was then employed, were watching Germany's rearmament. Now, what I have to say is in a kindly sense for a moment, and it may sound to you critical.

America likes to think in terms of personalities and slogans. Our advertising profession, if that's the right word for the advertisers, has built this up. And so we dispatched a wonderful man, a great pilot, to Germany--Colonel Lindburgh--to report on the state of German aeronautical art.

This was a grave mistake. You remember his famous speech--I think it was in Madison Square Garden--in which he warned that we could not beat Germany in a war. You may also remember that he came back and he infiltrated the Air Force with the theory that there should be no air-cooled aircraft engines; that the Germans had an inlined, liquid-cooled engine which, because of its more frontal area, would outperform any of our then radial engines to such an extent that they were obsolete.

Now, you may remember the history of the war, because you know more about it than I do, and you know the failure of the liquid-cooled, inlined engines. One bullet in the heat interchanger and you sit down. There were some other difficulties because the aerodynamic assumptions were incorrect.

The Chief of the United States Air Force called me down -- I was then head of Pratt Whitney Aircraft-- and told me that if you took the full power of our largest engine in a ~~lasalle~~ ?NACELLE and let it fly without any drag from the fuselage and the wings, with its full power it could not go over 455 miles an hour. I wrote it down when he said this, because it was so incredible that the head of our Air Force could believe such a thing. And as we went toward the door, he turned on me and said, "What are you going to do with those notes?" I said, "Nothing, General," and I tore them up and threw them in ~~the~~ his basket. He must have had a feeling that there was something wrong.

Now, he was the head of your Air Force--a man that I have the greatest regard for, as do you. But he was out of his element. Lindbergh was out of his element. The German technology was wonderful. It is today in any area in which they are free to perform. And it was their technology that allowed them to shake the world's security and bring on World War II. Their Panzas, their Stukas, their submarines, to take all three of their major arms, were far in advance of the rest of us. You know what happened with our torpedo.

So here is my second example of science and technology in world

security--for us, insecurity at that time.

Now, let's come down to something more recent. Let's take Quemoy. There was a nation of over 500 million people trying to take a little island within spitting distance off their shore. They couldn't take it. Why? Science and technology. You know what our aircraft did to their aircraft. You know what our amphibious landing techniques did in supplying the island. And you know that they are the fruits of science and technology.

Innumerable examples can be given to you out of your experience to show that science and technology are the key to your security, to our nation's security. With 175 million people we can't stand up to a world population of 2 1/2 billion or more and be a leading nation without science and technology.

This is so obvious to me that I'm wasting your time, but I was asked in the briefing for this lecture to compare us with certain other nations. Now, there isn't time to compare you with all nations. So I'd like to tell you the story of how France, the leading aeronautical nation of the world in World War I, fell to a bad sixth prior to World War II.

We could extract example after example, gentlemen, and the importance of the one I just cited is that neither science nor technology by itself will bring you security--overall science and technology. It is not enough to be a technologist of the highest order. It is not enough to be a scientist of the highest order. It's the team.

Now, let us try to define science and technology, so that we can better visualize what is meant by this team.

Very often you can be so close to the woods that you can't see the trees. I think this applies to what we are talking about here. All of you have in your mind what you think science is. All of you have in your mind what you think technology is. I would doubt very much that you would all pass a strict examination on this question, and I do not wish to infer that all of the knowledge reposes in me.

Many of you may not recognize that in the Manhattan District accomplishment, probably the greatest single scientific and technical accomplishment in world history, this question of the role of the scientist versus the role of the technologist was one of the most perplexing of all of the problems of the administration of that vast project. Time gets away from one here; and in spite of Dr. Einstein's statement that time is not fundamental in the universe, it is here on this platform. I'd like to tell you how in an effort to solve this problem, scientists were doing engineering work. In the design of weapons and devices, engineers were brought in. Immediately conflict arose.

So an attempt was made to teach scientists engineering. It didn't work. An attempt was made to get engineers who acted like scientists. It didn't work. So finally somebody said, "Well, I guess what we've got to do is to catch them young and train them. Let us now get some recent engineers who have now gone into research as a profession, but who have not been out of school long enough that they have hardened

their arteries in their thinking, and let us bring them into the project."

So a certain gentleman, Dr. Leo Linger, told me the story himself. Without knowing why, he was tapped at the Standard Oil laboratory in California and told to go to Argonne and report. He arrived at Argonne not knowing what he was reporting on, and a very tired-looking scientist came out to see him and handed him a big questionnaire. (You can't move in the Government without a questionnaire.) It was full of pages. He filled them all out, and got to the end and it said, "What are your hobbies?"

Well, he didn't know how to answer that exactly, but he wrote, "Camping, skiing, swimming"--things of this sort, and then he paused. The scientist, who was waiting for him to finish this questionnaire, said, "Can I help you?" "Well," he said, "I don't know whether to put this down or not. I belong to the Society of Amateur Magicians."

The scientist clapped his hands and said, "Brother, you're in. That's what we need on this project."

That only dramatizes the fact that there is a difference. It isn't a simple difference, but it's a real difference. So science, as I shall define it for you today, is essentially taken from Lord Kelvin, one of the world's great scientists, in which he said: "If you can't precisely measure something, it is not scientific."

Think of that for a minute. This means, then, that economics is not a science, and you call it a social science. The reason it is not a science is because there is no average man. You can't precisely

measure a man. Yet all of economics deals with essentially uses by man; and as soon as you bring man into an equation, you do not have in a strict sense a science.

No two gentlemen in this room think alike, act alike, or look alike. I can't make a statistical survey of this room and come out with an answer how any one of you would act in any one set of circumstances.

Psychology attempts to do this. I studied psychology, and it taught me many things. It taught me mostly the limitations of psychology, and the intelligence quotient systems, and the rest of it. If you have a son who has been the victim of one of those, I can only sympathize with you, because they do not apply universally. Sometimes the most brilliant mind gets a very poor rating.

They apply only statistically to maybe 80 percent of humans. This is not science in the sense that we are going to talk about it here today, because in the Lord Kelvin definition of science, it doesn't matter whether you're a Chinaman, a Russian, or an American--and I'll give you an example--the size of an electron. This is measured precisely. In the centimeter system it's 10 to the minus 21st power. And it's measured just as precisely in Tokio or in Moscow as it is here in the United States. There is no average electron.

So, now, science deals with materials and forces, with the behavior of the universe, in a measured, repetitive way. And it has also been said by great scientists that science has progressed no faster than the instruments that it can devise for its measurements. You see, this

is another way of backing up Lord Kelvin. It's a more modern approach.

This is why we build the 200-inch telescope. Dr. Gold, in your paper this morning, in his statement shows some of the fruits of one new instrument. This great thing that the Air Force is going to build in Puerto Rico for measuring the energy of electrons in the Van Allen belt, where the radar energy alone is enough to kill a man, where the dip will be a thousand feet--this is only an instrument, and the science of that Van Allen belt will not progress one bit better than that instrument.

So now, when you talk about science, please remember that you're talking about something that must be measurable precisely and repeated over and over again and always with the same results.

Now, let me dip again into social science, not that I am in any sense trying to say that a social scientist is not authentically necessary, needful, professional, and important. If anything, I'm trying to show you that he has the toughest job of all.

But the law of supply and demand, which had stood up as a textbook law in economics for so long, was suspended politically by one of our recent dynasties here in our own Government. It was a dirty word, and here in Government you didn't refer to supply and demand. It was stated that it was a fallacy. And all sorts of economists gave lip service and actual service to this change of viewpoint. Today it's slightly more fashionable than it was, and now there's an honest difference. But it is an acknowledged principle, at least worthy of study and reflection.

You don't treat the law of gravitation that way. And when Newton first worked out the mathematics of gravitation, no one has changed that today, including Einstein, who modified the law of gravitation, which is an argument that can be thrown up on the other side, because all Einstein did was to show that there are minute errors in the law of gravitation as announced by New ton, which could not have been perceived with the instrumentation of that age. And it took him from 1905 to 1919, I think it was, to prove that there were such errors, they were so subtle. Having proven the errors and furnished the theory, we now have the Einstein Theory of Gravitation, and his attempt to work out a unified field theory.

This is science. So now try in your minds to see the difference between science and other bodies of knowledge, whether they are political, economic, historic, lingual--it doesn't matter--they are not scientific. It doesn't pay to call them social sciences and thereby try to make them sciences. They are not. And the only reason they are called social sciences is because of convenience of administration in educational establishments, and the fact that they do use some scientific techniques, such as statistical techniques and the like.

All right. Now technology. What is it? Now, gentlemen, you are off and away from science. If you think an engineer is a scientist, you're making a great mistake. It's just as big a mistake if you think a scientist is an engineer. And this is the most common mistake in the Military Establishment--to get these two fellows confused.

Now, the engineer has to take science and harness it for the use of man. An example is the building of a bridge. The mathematics of the calculation of stress is scientific, but the application is not. Why? I've been asked to build a bridge between these two banks of a river. So my first question is, How large a bridge? The answer is, Well, the bridge should be large enough to take care of the traffic in the next 50 years, which is our assigned life of the bridge.

Well, now, I've got a crystal ball. What is the traffic 50 years from now? What are the axle loads? What are the speeds of the vehicles? What is the traffic density? What are the social habits of the traffic that will pass over this bridge 50 years from now? Will everybody get out of work at five o'clock in the evening and have a Washington traffic jam? Will we have learned something and distribute the traffic load over a reasonable period of time? Will our social concepts ever catch up with some of our generated engineering science problems? I don't know.

But I've got to know. I have to design a bridge. How many lanes wide will I make it? Well, I've got to know what traffic is going over it. How do I know how much traffic is going over it? Well, I must first decide what the road systems are that feed this bridge. What is the growth of the towns on both sides of the river? I'm not going to carry this any further. The engineer's task is not scientific. It's a social science in the sense that the poor economist has to work in.

Now, the minute you train a man to think in those terms, gentlemen,

you have destroyed him as a scientist, because he must come to intuitive decisions. That engineer must intuitively look in his crystal ball and decide how big these communities are and what the road systems are going to be and what the vehicles of the future will look like. This is not science. It can't be measured.

So the engineer is a man trained to use his intuition, and the scientist is a man who looks down on intuition. It isn't measurable. They don't think alike. They don't act alike. But as a team neither can exist without the other.

The scientist becomes sterile if he just simply locks himself in an ivory tower and grinds out new theories, even if he proves them experimentally, which is, of course, the tool of science. The engineer is sterile if he never has any new or more modern knowledge to apply to the solution of his problems. He becomes a mere technician.

All right. Let us say for the moment that we have defined science and technology.

Now, the scientists fall into two brackets--the theoretician and the experimentalist. And they are just as fixed in their little habits of mind as the difference between the engineer and the scientist. At Las Alamos the argument has never been settled as to whether the theoretical scientist postulated the size of a critical mass first, or whether the experimental scientist determined it by cut and try and fed back to the theoretical scientist the algebraic terms to put in their equation.

Now you see the conflict in those two professions, or aspects of a profession. These things you must know if you want to understand the role of science and technology in national security. It's the overall team, the overall capability, that you must examine and look for. This is what is involved in the moon shots, the Lunik, and the Sputnik, and the race that is going on. This is why some people orate on our importance in equalling or surpassing these Russians' spectacular developments, versus those who say, as has been said, "Don't waste your effort on those things. You've got to lick them on the intercontinental ballistic missile trips." It isn't that simple, in my opinion. You must come to your own.

Dr. Berkner on this platform gave you a very fine talk, which I attended, before this class; and he outlined the tools that we have in our country to try and bring ourselves up in this world conflict of science and technology. I have found it a very interesting paper, and I have read it several times since. I read it when I came here, because I didn't wish to duplicate or conflict with the story he gave you, which was a scholarly story. Now, he's a scientist. I am no. I'm not even an engineer. In nineteen fourteen engineers were a little different than they are today.

And so I did very earnestly wish to see what he would tell this group. He outlined for you the resources that we have in this country in this race vis-a-vis Russia, but from a scientist's point of view. He essentially gave you a very scholarly scientific point of view, and a

good one, and from a man who in the scientists' own category has degraded himself by becoming an administrator.

Now, you must understand what the scientist means by that. The Princeton Institute for Opinion and Research has made an elaborate study on this question: Why do scientists look down upon scientists who become administrators? I could say the same thing, since I work a little bit on the fringes of education. Why do professors look down upon men who become deans and presidents of educational establishments? How many of you know the old definition of a dean of a college? A dean of a college is a man who is not smart enough to be a professor, but too damn smart to be president of the university. In other words, as you go into administration, you go down grade. The further you go into administration, the further you ~~go down grade~~ are down-graded.

Now, scientists have this feeling innately, and the Princeton Institute has tried to find out and evaluate these factors. Its report is fascinating for any of you who have to do with administration of these kinds of people, to see why they look at you as a very inferior individual.

I think the time has arrived for subjecting you to some exhibits. (Chart 1) The tool of science is research. The tool of engineering is development. There is no fine line between research and development. So we have to show it more or less en masse.

Now, I cannot go back to the start of research and development in the United States, which historically was about the year 1900-1903, with the first commercial laboratory at Schenectady, with seven scientists.

Prior to 1900, all of this function was done by so-called inventors--Thomas Edison. The process of invention is totally different from the process of research. Research is a team effort--combining men of different disciplines and knowledge together under a leadership.

On this chart you will see that as we entered World War II, the total amount of research done in the United States was on the order of 300 millions of dollars--about '38-9. It isn't on that chart.

You will notice that in World War II the amount of research jumped in a period of about a year and a half to a billion 200 million from this 300 million level--a tremendous, gigantic increase. It doesn't show on this chart, because this is one of the limitations of social statistics. I had to make the chart big enough to bring you reasonably up to date. This makes these early efforts seem fairly inconsequential. They were not. They were fantastic in their impact and in their total mass effect. We had discovered under the critical condition of national security the role of research. So, as you see, it ran up, and then it proceeded to come down under the "Bring the boys back home by Christmas" philosophy.

Now, you will notice that that little, fine curve underneath, which is the industrial research, did not come down. Here you have one of the great advantages over Russia in this simple curve. Industry thinks for itself. Government responds to planning.

Now, the biggest Achilles' heel in the Russian system is that it's a planned system, and it is not one bit better than the plan. It can't be. The planning is by a few. Under our system the planning is by the many.

And under any social statistical approach, as an engineer I would like to say to you, I prefer the many to my picking out these I.Q. wonders and turning over the security of my country to them.

So here industry said: "Look. We have discovered this tool of research and we do not turn back." You will find that from that time on, there never was a turning back by industry.

On the other hand, there was by Government; and it was a very serious turn-back. I had to appear before the Congress at that time in making a plea for continued research for our own security. I have never forgotten it.

Now, if you will look at Government research, you will see today where Government research stands vis-a-vis industrial research; and you will see that the hard-boiled free enterprise gentleman has been thinking pretty hard.

(Chart 2). Over on the left you will see where the money comes from. Industry only puts up two thirds of the money and the Government a third. That 3 percent at the top for the universities is the most important part of the chart. That is the money that goes into this so-called basic, fundamental research, without which the rest of this thing would wither.

Now, over here you will see that the universities get help from the Defense Establishment and other pieces of the Government, and so they actually do 6 percent of the work. The Federal Government, with 33 percent of the money, does 15 percent of the work. And here is your

free enterprise part of the pie.

(Chart 3). Now, I have to move fast here. I always make the mistake of coming before you with too many samples in my bag. Here is Federal obligations. This is only the Government's side. These are three successive years. You will see the degree of growth in the total research in the life sciences, the physical sciences, and down below the social sciences. You will see that the social sciences do not take the amount of money that these others do; and, of course, most of their work is done with pens and pencils and IBM computers.

(Chart 4) I don't know whether you can see the title of this. It's the Federal obligations for research and development by character. Here you will notice that the black is the total conduct of research and development. This dotted gray is total development. And then you have total research and basic research.

I put this chart in for you because I want to reemphasize our deficiency in basic research and the fact that I am an optimist and I believe our country responds to its deficiencies, because the growth in this (basic research) percentagewise is far greater than the growth in the other. This is one of the finest things that I could put on the board for you, even though the amount of money that goes into it is quite small. But the value of that, which is this little 6 percent thing which you saw on the university chart, is the key to the whole problem; and it certainly is the key to moon shots.

(Chart 5) This will give you the Federal obligations for research

and development by agencies. At this point you change the chart. This is a different ~~chart~~ scale. So, taking the top here, you will find that the bulk of the money goes to the Department of Defense. Those are billions of dollars. Underneath that you find the Atomic Energy Commission, and that, as you see, is hundreds of millions of dollars. When you get down here, you get down even below a hundred million dollars, and you come to the Department of Commerce, with the Bureau of Standards and the Weather Bureau and a lot of very vital things for you, which, again, were covered in Lloyd Berkner's speech, and you will see that in millions of dollars it's comparatively small.

You will find that here, this really belongs up with Defense, although it is listed down below. And that, of course, is the Advisory Committee for Aeronautics. You are going to have the Space Agency on a more modern chart, but those statistics are not yet available.

You will notice from the civil point of view that this ~~admx~~ Education and Welfare is taking now a fairly large slice of the research money.

(Chart 6) Now, here you have the trends. This I think is quite important to you gentlemen. This is the percentage of the Federal budget that is going into research and development. You will notice that this is continuing to go up. This is the recognition ~~throughout our~~ throughout the Government of the role of research. And you know that your weapon systems become obsolete in a relatively few years in the more advanced types of systems, and longer periods for the more stable types of systems; and therefore

it is here that you ought to be putting your money, because you can't do this under conditions of war too quickly. Timing is the essence. Up above you find the Federal trends in scientific research and development in billions of dollars, and you see that it's a nice-looking curve. But this is the one that you have to watch (percent of total Federal expenditures).

(Chart 7) Now, this has to go on to show you our deficiencies. I have only got on this one chart U.S. and Soviet engineers. You will notice that back here in 1952, as we came down off the war curve--G.I.'s who went to college--the Russians, who are pretty smart hombres when it comes to figuring out their own deficiencies, started on this fantastic curve.

Really, gentlemen, this is what I think Khrushchev meant when he said he's going to bury us. He fully recognizes that it is science and technology that determines what for want of a better definition I will call modern civilization. You would not have your civilization in this country if it had not been for the busy little engineer who ground out the automobiles and the radios and the televisions and the communications systems and the road networks and all these things that make modern life. You wouldn't have a civilization like this.

Well, then, if it is the engineer who has made it, let's see what we're doing in terms of our competition. And this to my mind is much more significant than trying to compare these economic statistics as to the rate of growth of Russia versus us. These are the people who

make it grow. I know that if there are lawyers and other people here, they probably think that I'm making a plug for engineers. I'm only making a plug for national security, because the lawyers really don't make the nation secure.

(Chart 8) Now, gentlemen, it's hard to find a measure for scientific excellence. I have come upon this one, thanks to the New York Times, and I want to point out something here for a minute.

These are the Nobel Prizes awarded. In other words, in the opinion of an independent world agency, where are the greatest scientists? So we use the Nobel Prize now as our measure. And you see the United States in physics got 8, Soviets 3, and other nations 11, out of a total of 22. This is since World War II, you notice.

Now, you take chemistry, U.S. 8 out of 17, with the Soviets one. Medicine and physiology, which the Soviets try to make the world believe they are so extremely advanced in, such as the transplanting of nerves and all this modern technology there, they didn't get one. Here we got 16. So you see the significance of that money I showed you on the earlier chart that we put into the life sciences.

Well, gentlemen, it looks pretty good. You ought to feel pretty nice at this point. But there's a joker. Who are these men who got the Nobel Prizes? Unfortunately, a lot of them were born, raised, and educated in Europe and came over here. They are not American-trained scientists. One of the problems in our universities is to get students who want to be long-haired professors in terms of the

theoretical sciences. They tend to all want to become applied scientists, because this gets the dough, this gets the kudos; and in the United States we run on a rule of dough. That is not as good as it looks.

(Chart 9). Here are the science and engineering graduates from universities and comparable educational institutions in the latest year that we can find them. I think this comparison is worse today than this chart shows.

You will find there that the science and engineering degrees are 90,000 in one year from the USSR out of total degrees awarded of almost a quarter of a million, and that the percentage of science and engineering degrees is 37 percent and ours is 19.

But now look here. England, 44 percent, France 29 percent, Germany 34 percent, Italy 26 percent. This is your Achilles' heel. You've got to defend our country. Here is your weak spot.

(Chart 10) Now, here is the U.S. versus Soviet institutions of higher learning. Notice that the United States has 1368, and the Soviets 762, which means nothing. Here were the students in 1955. Here are the baccalaureate graduates. My heavens, isn't this odd? When a Russian student goes to college, he graduates. This is unheard of. We're a free country. You don't have to graduate. Now, 80 percent of these fellows had all their tuition paid and they got a worker's salary in addition; and the Soviets require for that a quid pro quo--that he graduate. Furthermore, that his marks are fairly good. This guy works. He doesn't take the country club course.

Now, here are the technological students in the United States and Russia. There is your Achilles' heel again.

(Chart 11) Here are the Soviet institutions of higher education. Notice ~~that~~ their engineering and technical schools, in terms of their other schools. Here again are the figures that you saw on the other chart. Those are the figures. But now look. Correspondence schools. A Russian correspondence school is a serious piece of business. If you undertake a course in a correspondence school, it's much better for you to finish it. This is an additional supply, not shown on the other chart.

Now, the Military Academy one is the one that nobody is sure about. That's the most hidden thing and you can't get at it too well. But it's quite large in terms of our three service academies in any case.

(Chart 12) Here is something we don't have in comparable form. The Russians, with their state planning and education, have discovered, what we know, that everyone isn't equipped by nature to be an engineer or scientist, either one. Our educators have said that only 18 percent of our boys, youth--and it should say "girls" because we don't inherently look in that direction--although more and more women are taking engineering degrees in the United States, but it's still very small--but our educators say that only 18 percent of our youth have the mental equipment, motivation, and so forth to be an engineer or scientist.

Now, Russia discovered this; but she also discovered that there are a lot of youths in Russia that have the mechanical sense to work with

their hands skilfully. They think three-dimensionally. This is the essence of an engineer--to think three-dimensionally. Russia has learned that this is a vast reservoir. So Russia has set up a system called technicums. I am told they have 3000 technicums. Here it says 3753; so I suspect that's about right. And these people who graduate, who are large in number, are a supplement to their engineering graduates.

So the picture is much worse than I showed you. And you know, from time to time, particularly in Southern California, people say you waste your engineering talent. You have engineers out here doing drafting. You have engineers making material lists. Why don't you use a technician? They make perfectly fine draftsmen. Let them make material lists, et cetera, et cetera. But you require a four-year engineer. Russia does not.

Now, the one case we have in this country that follows this ~~book~~ philosophy ~~is in electronics by my~~ , of which I have personal experience anyway, is in electronics, because there there are a lot of schools--and certainly the Army, Navy, and Air Force all do this--that graduate technologists in electronics. These men you will find in our electronic factories making the bread board models. You will find them doing work that we would have engineers doing in the other engineering professions.

So here you've got an example in the United States where we have gone this route. But we haven't formalized it the way the Russians have. And this is again one of the advantages of their state planning. When the Kremlin pushes a button, it happens.

I think they're about to give their own educational system a body blow by following Khrushchev's latest line, which is that nobody can go to college who hasn't gone to work first. You have to work either on a farm or in a factory. He's doing this because he woke up and found out that the bureaucrat's sons were the ones that went to the universities.

(Chart 13) Now let's take another facet of the problem. We have talked about the engineering talent and capabilities of the two systems. Let's see if we can find any data in the social science realm that will back up the theory that it is the engineer that makes our civilization.

First off, your civilization is made by production--either furnishing you goods and services--and services are as important as goods--and this means transportation and the like--who does it, and how do they do it? I used to show a chart before this college showing that in 1855, in the Civil War period, men worked, physically worked, and horses worked. Now we have taken all the load off men and horses and we have put it now on our electrical distribution system. So that we bake cakes by electricity, and we mix things by electricity. We do everything by electricity. We wash the dishes, we wash the clothes, we iron the clothes. Everything you can think of now we just put another socket in the wall and go to work.

Well, this, then, would be an interesting test; and this chart is original, as far as I know, with me. I wanted to see how the figures furnished by the social statisticians of the Department of Commerce for our standard of living--which in theory ought to be, in old ~~practical~~ classical

economics, the kind I studied, the standard of living is the total of goods and services produced in a year, divided by the population, assuming that it's equally divided.

Now, you take the Department of Commerce figures as far back as we can get them. We take the Edison Electric Institute figures for kilowatt production as far back as we can get them. We know that there are some minor assumptions and errors in here, and I again say I am using statistics, which is not an exact science. And I used the definition before this audience before that a statistician is a man who draws a straight line from an unwarranted assumption to a foregone conclusion. Now, having exposed myself, let me say that I tried to give you the best I could get. I know there are errors in this. If there are social scientists in the room, they can help you point out what these errors are. But this is the best you can get that I know of.

So I have divided the kilowatt hours energy over the Edison system as far back as 1903, which is the earliest of record, by the population and I come up with the amount of electrical energy per unit of population in the United States over a 50-year period. Then I got the standard of living from the Department of Commerce over a 50-year period. By Jove, they run a neck-and-neck race.

This is like saying to you that your standard of living is based upon the amount of energy provided by your engineers from natural sources of energy--coal, oil, fuels, atomic and the like--distributed to the population, used in production processes and transportation and

the like--it's the amount of energy divided by the population, compared with the amount of goods and services that the Department of Commerce says each one of you statistically has as a citizen of the United States. You will find that the engineer has created the process of production and of distribution.

(Chart 14) Here are the standards of living of the world, as computed over in your College from the best sources available. You will notice that the USSR is down here. You will also notice that we are at the top. You will see the nations that are at the top. And every one of them is the kind of nation that you like to think about and is sort of like us. This is a very flattering sort of statement to make.

It's interesting that such nations as France, which we have seen going through quite an economic struggle, are fairly well down the line, not too much behind the United Kingdom, which has had its struggle. These figures are for '57, and I assure you they would be a little different today. But when you get down to here, these figures don't mean so much, because the statistician cannot collect the statistics for some of these more primitive nations. Again, I have used the example that a man in the Philippines gets hungry and he wakes up, has a feeling in his stomach that says he had better eat. He goes out of his little thatched hut and ~~walks~~ wanders out and comes to a banana tree and pulls off a banana or maybe four or five and eats them. He feels better. But it doesn't go through the statistics at the First National Shopping Center. And so the standard of living down here is to some extent, I think, a phony.

Nevertheless, it would have to be vastly different than the statistics show to be a really important factor. So you can accept that, whereas it may not be accurate, it at least is meaningful to show it this way.

Now, our security today, in my humble opinion, is based upon our population times our standard of living. That's what you have to fight a war with, plus your capability, which means morale, and this means science and technological know-how. You put them together and bake a cake and that's your security.

(Chart 15) There's your gross national product, which in a sense is what we've been talking about. Here you will see that for the United States, Western Europe, and Canada, which we will call our team. It looks pretty good. Here's USSR. Their team looks kind of skinny. On the other hand, the percentage of this (USSR), these factors, which are used by USSR for what we call security reasons, is much higher than ours. And so we can't use this comparison too specifically or too directly. You see, there's an error in these figures here, which you can rapidly figure out for yourselves. Nevertheless, we have a preponderance of strength in terms of gross national product still.

Now, of course, it's interesting for you to assume that the Russians could overrun these NATO countries and knock this out and then harness this down into their team in some percentage thereof, and you will see how quickly that would change. But you study these things anyway.

(Chart 16) Now, this is an interestingc curve to me. It's the economic growth of the United States versus the population. Here is

Here's your population growth in the U.S. But this is the gross national product growth. This is the busy little engineer at work up here. This is supposed to be constant dollars. I never met one, but I guess for statistical reasons we can use them.

What you see is that this period of great growth corresponds very accurately with the period of research. You saw the growth of research on my first curve. That's like saying that the products of research, harnessed by engineering and energy, produce this enhanced state of the economy.

(Chart 17) This chart was furnished by the Ohio State University at a logistics conference which I attended, at which this college was well represented. And here you will see another interesting thing--that the total number of engineers per thousand of total population curve in the United States--this is total now--checks up with the gross national product. This is merely another exhibit to indicate to you that there is some basis for believing that the amount of engineering talent that you have, provided it is all fully employed, will determine your gross national product.

Now, here is another example of the difficulties that social scientists have even in dealing with themselves. As far as we're concerned, there isn't anything any better. So we just take it. Engineers are used to this. If you haven't got a material that has 300,000 pounds per square inch ultimate strength, you take one with 200,000 and do the best you can. So that's what I am doing with these statistics. This is kind of ordinary

engineering.

(Chart 18) Now, there's your electric power available, which in my opinion is synonymous with gross national product. You will find these same ratios. So you watch now carefully the growth of power resources in Russia and China if you want to catch up with what I think is their real capacity to make and sustain a war.

(Chart 19) This is a dramatic way of saying to you that the United States, with one-sixteenth--that's 6 percent roughly-- of the world's population, produces one-third of the power. It's another way of saying that it produces one-third of the war-making potential or the total standard of living of the nation, not of an individual, or the gross national product. I know that there are little errors in these generalizations, but they follow; and I have shown it by trends. So that it isn't mere opinion. The exhibits reflect the fact that these relationships exist. That, of course, is fantastic; and this is what Russia is shooting at. They are trying to bring their picture up more in consonance with this one.

(Chart 20) This is what he's doing. This is a comparison between the U.S. and the U.S.S.R. The U.S.S.R. is the black figure and the hatched ones are ours. This is the year 1965. As you see, it's a very modest increase for us. But percentagewise it's a big increase for your enemies.

And so you notice that these figures, which are coming out, which are so misunderstood by those who read too rapidly, do show a higher

percentage per year improvement in Russia than ours, but from a different base. And, of course, one theory of social science says: "Well, sure. This is inherent. The child grows faster than the adolescent, and an adolescent grows faster than a mature person, and we are a mature economy, and they are an adolescent economy; so naturally their percentage of growth is going to be faster. But they are going from a lower base level." This would tend to indicate that.

Well, now, this is Khrushchev's own curve. That's what he tells the world. That's what his plan is to do by 1965. But this is where we are today. You see, we had a downput. And when this thing occurred, which was the recession, the Russian Ambassador delivered a speech before the National Economics Club in New York in which he just tore our economy to pieces. He used this figure here and that one, and he showed how--"You see, with our system, we don't have these recessions and set-backs. We're going right ahead. You're going back. You're a decadent economy. We are a progressive economy." And so he drew some lovely conclusions by the rule of the definition of a statistician given to you earlier, and showed that these two are going to cross up here, you see.

All right. Now, this is the minimal basis and that's the maximal basis projected for the next ten years of the growth in the U.S. This is zero. So you see, the USSR still has to do some pretty fast growing to make good on what Mr. Khrushchev said when he said he'd bury us.

Now, you see, I seem to be giving you hope now, after having

plunged you into despair in the earlier charts. And, of course, I hope you'll come to the conclusion that life isn't simple and that these are all things that you should study, weigh, and know--correct the bad ones and nurture the good ones.

(Chart 21) Now, these are six specific goals, taken out of the overall goals. The middle curve is the USSR today and us. And you notice on steel, due to our steel situation--we have a steel-making capability here of 135 million tons, and notice we only made 80. He has a steel-making potential of not much over what he makes, but he runs it all full. He prints rubles. We only print some dollars. He prints rubles. And so he runs the steel industry full. Ours reflects only the demand under the free enterprise system.

This is true--this comparison. When the Russian Ambassador made his speech, it was worse. We weren't running at 80 million then. We were down to around 70 percent of our then capacity and it didn't look so good, and they were going full blast.

Now, that's what he says he's going to do. So he now tells the world, you see: "In 1965 I'm going to make more steel than the U.S." For peanuts he will. We can make 135 million tons now.

So when you read the papers, try to use a little analysis on what the papers are telling you.

Here's oil. He's done a fine job in oil. He's got a lot of oil. Here's what he claims he's going to be doing. If he does, I'm afraid the world price of oil is going to take an awful nose dive, because with

the French new development in Sahara, and Venezuela having more oil than she can really market, there's going to be plenty of oil. And the old theory that we only had eight or ten years of oil ahead of us is a discarded theory.

Here's electricity, and this is the one to watch. In my opinion these two (steel and electricity) are the most significant. There you see where he stands in electricity and what he claims he's going to do. And, of course, we don't claim what we're going to do, but I can tell you. The electrical industry plans on doubling this in ten years. So that by 1968, or three years past this, our stock is somewhere up there in the curtains. I can't tell you where. But, anyway, you have him caught.

Now, here's meat, which is quite interesting. Look where they're living now. Remember, They have 225 million people to our 175. So you also have to dope these up a little bit if you're talking per person now. So they don't eat too much meat. This is what he hopes to give them.

Now, here you've got butter. He crows over this. He's licked us on milk production and butter production, which is quite interesting. And, as you know, these are substitutes for meat in the diet.

Here it is for shoes. It used to take about a month's work for a man to get a pair of shoes. I think he's improved that situation materially.

So, you see, there are a lot of things for him to crow about to his own people.

(Chart 22) This is that doubling every ten years that I told you about. It is an fantastic thing, gentlemen, but since 1903, when these figures started, we have doubled every ten years. And that means

two to the fifth power, which means we have increased our electric capability 3200 percent in 50 years, or 32 times.

Now, of course, if in the next ten years we double it again, it will be 64 times. And then, if we do it again in the next ten years, it will be 128 times. These things get fantastic. But the strange part of the thing is that we have run on this exponential equation ever since the 1900 period. And this is the projection of our own Electrical Institute members.

(Chart 23) Here is something very significant. This is the pounds of coal per kilowatt hour. And, of course, this is very vital to you, because the world's and our own supply of minerals is not an easily definable thing, because the rate of consumption is not constant. You see, we're down to really two-thirds of a pound of coal on the latest planned stations here.

Now, if you go back to Thomas Edison, which is 1882, it took him 19 pounds of coal to make a kilowatt. Now I'm off the subject, but only for one second. When you read this, to my mind, hogwash about atomic power not being competitive, please remember that the first generation of atomic power plants will have their economy improved very much as you see in this curve if you extended it back to 1882, by an enormous amount on each successive generation of design. You'll never improve them if you don't start building them, because the engineer learns by doing.

And this is what's wrong with your ANP program. You've got a

lot of people fishing in that pool who don't understand these things we're discussing. And if you will read the history published by the Joint Committee under the first open hearings, you will read the best case for fuddlement and befuddlement in the Government that I know of that has been published for the public to see. It's something that you all ought to pick up and study.

Now, the interesting thing is that scientists have been making engineering decisions. I lived that process for five years, so of course I'm a partisan. But I had to fight Dr. Oppenheimer and Dr. Conant, who were making engineering decisions and did not understand engineering. And what they don't understand is that the engineer learns by doing; and that the first ANP airplane ought'nt to be a service airplane by the latest performance. It's got too many untried things in it. It ought to be something that flies. You ought to put your Air Force officers in it and fly it. You ought to find out where its maintenance problems are, what your landing problems are, what your hazards are. And it'll be a wonderful machine at that, because it certainly could patrol the sea for the Navy and watch the submarines as long as the sandwiches and coffee hold out for the crew. And you haven't got anything like that. It's the Nautilus of the air.

But what do we do? We've got a lot of scientists involved and they say: "Look, this first turkey you're going to fly only has transsonic or subsonic speed, and that's out of date." Well, this curve is to show you something about engineering. The engineering curve

of improvement is one of these exponential curves, where the first attempts are greatly improved by the second attempts and then greatly by the third, but in a lesser degree, and to a lesser degree in the fourth and fifth and sixth; and you can see in this curve you come down a sweeping path.

Now, sure, when I say that the latest plan for power generation is two-thirds of a pound instead of three-quarters, it doesn't sound like much. But try that percentagewise on your slide rule. It's a terrific improvement. And so it is still going on.

This is what you will find in ANP. This is what you will find--and Rickover very carefully brought this out in the hearings on his submarine power plant--when he said the Nautilus ran 60,000 miles on its first course. On its second course it ran 90,000 miles--50 percent more. The third course we now have designed and on the board where it will run 135,000 miles.

This is what I am talking to you about. If you waited for 135,000 miles capacity on its endurance course, you would never have built the Nautilus. You would be like the ANP program--waiting for something that just wouldn't happen. You got there by doing it. That is what you need in your ANP program.

That is true in any engineering program. I'm using that because I knew most of that. I knew why it was blocked. I knew who blocked it. And let me pay a testimonial to our Congressmen. They were the one body of men who never took their eye off the ball. And the ?

example--those are the people who blocked us. It's a very interesting study, gentlemen, for any of you who are in military planning procurement, to see how a democracy can fuddle itself up on what are strictly subjects for today's talk--the role of science and engineering and technology in national defense. It's a wonderful example. Here I put on this just to show you this engineering principle, which has now been going on now since 1882.

(Chart 24) Here is the U. S. Government's investment in the atomic energy program. This follows Parkinson's Law. As you will see here, it's around two and a quarter billion dollars now as an annual appropriation for this. There's a grave study being made on, What should these big laboratories that they are building be for? It's a nice time, after we've spent it, to find out what they're for. It's a serious inquiry.

Are we really socializing atomic power? I'm not answering the question. I'm throwing it to you, because here's a case where secrecy has so locked in the program that it doesn't work. It doesn't go forward in a democratic atmosphere. You can't hold hearings on a lot of the things.

It's an interesting thing to study. As far as I'm concerned, it's the best, the very best, investment that this country has ever made was the two and a quarter billion dollars that it paid for the first atomic bomb.

I know my time is getting late, General. I can wind this up and not finish this. What is your pleasure, sir?

GENERAL HOUSEMAN: Let's go on.

MR. WARD: You asked for it. What I want to tell you about this thing is something subtle. When did this new science of special weapons start, who started it, and how did it get where it is, and what should you know about it?

It started in 1890. A German, Dr. Hess, proved the existence of electromagnetic waves. No military man gave it the back of his hand, I am sure. Neither did the public. They didn't know that when he did that, they would revise military communications and that they would some day furnish the greatest power that the world had ever contemplated--the thing that made the sun operate.

Five years after that Dr. Roentgen came along and identified X-rays, which are nothing but hard electromagnetic waves. The year following that, Dr. Becquerel, a Frenchman--please notice that these are not Americans--discovered and proved radioactivity--a still harder form of radiation. The next year Dr. Compton, an Englishman, proved the existence of the electron. The next year a Pole, Madame Curie, isolated radium and determined the laws of atomic radiation. Three years after that, a German, Max Planck, brought out Planck's Constant, which is as great in its field as the Einstein theory except that it is not as easily understood. It is the basis of the Einstein Theory. There would be no modern science without this purely intellectual, mathematical, physical discovery of Max Planck.

In 1905, five years later, Einstein produced his special theory

of relativity, proving that E equals MC squared--not proving it, but stating it. Nobody believed it. Only eight physicists, I am told, even would go along with it. But, gentlemen, that's the basis of your special weapons systems--right there.

Now you see the steps in its labor pains. And not a military man was even conscious, nor was the public, nor was the bulk of the scientists, and certainly no engineers. They didn't even understand it. It took him until 1919 to prove that it was so. By then he had his general theory of relativity.

Now, in between, Lord Rutherford, a New Zealand Englishman, proved the nucleus of an atom and the anatomy of an atom, which Niels Bohr, the Dane, got the Nobel Prize finally for reducing to carefully measured parameters. That was 1919. Then there was a great period in which Lord Aston, an Englishman, produced isotopes. The positron was discovered by Anderson. We built the cyclotron in 1932.

Then we had a machine for testing these principles. Up to then this had been largely theoretical research. Now, all of a sudden we build this--the Americans. They're the doers. They're the hardware boys. We came through and got the Nobel Prize for building that cyclotron at California. And when that was done, then the art began to develop experimentally. Up to this point it was largely in the hands of the theoreticians. This is how your special weapons were born, and still no military connotation at all.

Then, after that period--and I'm skipping over a number--we come

to the Enrico Fermi period of the change of elements. Here's where he proved that we could build new elements in the periodic table, and he developed this patent for the control of the energies of neutrons, which formed the basis for your whole weapons development in the Staff Field reactor. An Italian.

Now we come to the great [redacted] accident in Germany, when Dr. Hahn and Dr. Strassmann, fooling around with the California cyclotron, had an accident and couldn't interpret it. Lise Meitner, a Jewish girl, was expelled from Germany, but she witnessed it; went to Sweden, went to Niels Bohr. They interpreted it. And your Manhattan District was born.

How many of you know that history? How many of you realize how your greatest weapon system came into being, and what the relationship of science and technology is to how it came into being? Notice, this is science. Engineering hadn't entered into it.

Enrico Fermi built that first power generator under the Stagg stand in Chicago and two years after Hahn and Strassmann had their happy accident. And then the fight was on. And in the extraordinarily short period of three years we had reduced it to a weapon system, the greatest weapon system in all history.

What an example to study! What a thing to look at to see where national security originates and how, because Hitler had said this was going to be his secret weapon to rule the world; and when [redacted] Alsop went over to Germany with the front-line troops and examined what

Hitler's people had done, he found that he had built a reactor which was going to be a dud, and the scientists told us the reason was that the politicians were mixing in on it. This is what they are doing to ANP. So there's a lesson. You can find it abroad. You can find it here.

This is what you ought to know about the science-technology team, in my opinion, because you are boys that have to take these things and put them to work to preserve this security. But must know how they come into being.

(Chart 25) I put that chart on to give you a symbol. Russia has her symbols, like we do. This is Sortadovno, near Moscow, and it is the largest atom smasher in the world, six times as large as our largest now in existence. We will build some as powerful, but this is in existence and has been for some time. Dr. Wilson, of Cornell, with whom I have discussed this, who went over at the invitation of the Russians and saw it, tells me the following:

This instrument has not one principle in it that we don't know. But--and this is the shocker--all of the engineering which makes this instrument work--what are they? The vacuum system, which is a very high vacuum, large scale; the electron and proton gun systems; the electronic impulse system--mind you, electronics. I always thought the Russians were backward in electronics--are superior from an engineering point of view. This is a scientist talking--from an engineering point of view to the best that we have in the United States.

Gentlemen, the threat of Russian engineering is a real one. This

is the symbol that I want to leave a picture of in your minds, because in a country where there's only a hundred square feet per person for living, they build this kind of a monument to house an instrument in pure theoretical and experimental physics. This is a symbol to the Russian people and the world that the challenge is on.

You, you will shortly be relieved, and I would like to do something I don't like to do--read a short summary now of some of the ideas I have tried to touch on. Even if they are somewhat repetitive and I have to read them, I hope you'll bear with me.

Science and technololgy can only flourish in a national environment of superior educational facilities, plus the availability of ample energy resources.

It requires that there be a full understanding of the role of research and particularly what is popularly called fundamental research.

Note the effort that Russia is making in all of these areas; I mean education, fundamental research, and science.

The impact of technology is more obvious than that of science, particularly to the Military Establishment. That's where you meet these people--in the hardware.

The officer cadres must be based upon a wide diffusion of technological know-how and of specialists. I happen to be sitting on the Secretary of the Navy's board for the education of Naval officers in the future. The Navy is giving this great thought, as I am sure the other services are too. It isn't simple.

This in turn requires superior training techniques and facilities.

The question is asked, What will be the principal responsibility of Government with regard to pure science? The answer, my answer: To accord recognition of the role of science in major governmental activities through the appointment of high-level scientists close to the decision-making process. Not in the decision-making process. This is what killed ANP, and it has done some other severe damage. It should be close to the decision-making process. You're the gentlemen to make the decisions. You've got to use these things.

To encourage basic and fundamental research, for which there is no appropriate reward in private industry, and to make available expensive facilities for certain types of research which would be beyond the capability of private industry. Lloyd Berkner gave you a very fine talk on that; so I will not repeat.

To encourage the training and education of scientists and engineers within and outside the Military Establishment. This is what the Navy board is giving great thought to.

To recognize the role of science and engineering in our national educational policy. What do we mean by that? There has been much bad public relations with respect to engineering and scientific education--too many engineers, too many scientists--this kind of thing. This has affected the vocational counselors and advisers in the secondary school system.

Lastly, to see that our intelligence is equipped and oriented to

follow the development of world science in all languages and cultures. I have served on several Government bodies that have inquired into this, and on the whole we haven't been too alert. When our scientists and engineers go to Russia, they quote our papers. They are sometimes more familiar with them than we. But we can't quote the Russian papers. They are not even translated except for a very limited number of publications.

We have tried to define in understandable terms science and technology. We have examined the environmental factors in various regions of the world necessary for science and technology to flourish. We have cited examples of countries of limited size and of resources becoming world powers through science and technology and their employment. It is all too obvious to point to the many examples in weapons technology without which no major world power can claim to exist in security. I don't have to mention that. Where would we be today without special weapons in the world jungle?

Admiral Arleigh Burke's recent testimony to Congress on the Russian ballistic capability and Khrushchev's stated ability to place missile-launching submarines under the icecap in Hudson Bay for a precision surprise attack on the United States is a current and frightening example of a threat and a challenge to our own military posture.

The obvious example of the employment of science and technology and strategy in recent times is the creation of and employment of large nuclear explosives, air-delivered. Automatically this has determined

the basic strategy of the three nations capable of building and employing such weapons today, and the strategic roles of those other nations through treaties of access to such weapons; and, lastly, the strategy of those other nations which do not.

We have shown that Sputnik alerted the American people to Russian scientific capabilities and opened up space science, with its challenge to future security through new science and technology.

Gentlemen, space science. I hadn't time to include that today. But if the Russians succeed in their plans in space science, they will have a weapon that will top us. All of you know what it would mean to have air-space ~~reconnaissance~~ reconnaissance 24 hours a day, and what this could do for you in your military planning alone. But it goes far beyond that.

The outstanding lesson is that not alone must the factor of science and technology be recognized in its fundamental role in determining strategy, but that the competition for still newer concepts is essential for the future security of any world power. You can't stand still. You can't stand on your special weapons and ignore space technology.

In the long run, scientific and technical capability almost alone, ~~will recognize and properly employ~~ where recognized and properly employed, can determine the security and thus the leadership for any major nation in any future world political struggle.

Does an intelligent, alert American need any further proof of

the role that its own science and technology must play in establishing national power for its own security into the future?

CAPT. FIKE: Mr. Ward is ready for your questions.

QUESTION: Do you believe that one of the possible solutions to our dilemma of not being able to produce enough scientists and engineers would be more Federal aid to education--something on the same order as the G. I. Bill of Rights?

MR. WARD: Yes.

Now, the method of Federal aid is important. Let's go back to something I know a little about, and that's the Navy's approach of the moment.

It has been said by one distinguished admiral who came into the Navy and has received all the highest awards since--he came in from outside life--a professional engineer. He pointed out that with the growth of complex weapon systems and the need for this technology within the Naval Establishment, complemented by the big shortage in the civil component, the country was losing a great resource insofar as the Navy enlisted personnel were concerned who were competent to take baccalaureate level education, but who for reasons had never done it. Either they were not motivated, or they didn't have the money and the resources and they had to go in the Navy as a means of making a living and getting rid of their military early service.

So the Navy started two programs, called NESAP and NEAS. They held competitive examinations in the enlisted personnel and found that, sure enough, they had people with these capabilities.

And they started an experimental program.

Now, it isn't fair for me before this college to give you what I think the Navy thinks. I am only the chairman of this thing. You know how the service works. But this much I can say: The first crop of these fellows going to schools of the top caliber--Purdue, MIT, and the like--that the educators, Dean Westman of Washington University, and the others have made a report showing that these enlisted Navy personnel have higher marks than their regular enrolees and a far lower percentage of those who can't or aren't going to complete.

Now, I haven't answered your question. All I've done is ~~just~~ to sketch the background. Now I'd like to answer the question.

Sure. The Chief of the Bureau of Navy Personnel was asked by this committee to widen the program because of its success. His first answer was, "Where do I get the money?"

Now, the admiral who introduced the program said: "But look. Even though you're saying that your ability to hold these officers within the Navy after the educational period and their full enlistment is over, and then they go out in civil life, the country is stronger by these men." This adds to our national security--my premise of the day. Therefore this is a proper function for the Defense Establishment, not an improper function. It isn't taking over the role of the Department of Education, Health, and Welfare. The Navy agreed, but they still said, "Where do we get the money?"

Now, my own feeling is that we are not ready, or shouldn't be

ready, for the regimentation that is behind the Russian approach. But lest you be drawing wrong conclusions, the Russians do not order these young men to take engineering. They offer them the opportunity. They offer them all of their tuition, a higher rate of pay, a guaranteed employment upon graduation at several times the financial reward if they merely take a non-scientific, non-technical course at the university. This is the bucket of oats in front of the donkey. It is an incentive system.

Dr. Colin Clark came to this college last year at my suggestion and gave a lecture on an amazing thing--that the Russians are moving toward free enterprise more and more--meaning the use of incentives--as we in the United States move away from it toward socialization. This is by an Englishman. He's now in the Econometric Bureau in New York. He's rendering great service to our economic profession, in my opinion.

Now, I answer your question this way: I do not like to see a regimented program of any kind. I said, and I used in my talk, public relations. Our Government could well afford to bring its considered opinion through its Department of Education through the educational fraternity in its meetings and its colloquia and all of these devices which the Government has for bringing Government thinking into the civil components. To start with that. And then see if the civil components will not respond.

I am a perennial optimist. I believe they will respond. I believe the trouble lies in an incorrect appraisal of the need of this problem for a solution. Give the American public the right facts and I think they will act. I don't think you have to do it by another big and now impossible

item in the budget.

QUESTION: You hit on something which generates this question that I'm going to ask you. That was that the Russians did guarantee these engineers a job upon graduation. My question is that in an economy such as ours isn't there a law of supply and demand with respect to the utilization of engineers, and would it be a solution to the problem to go ahead and generate a lot of engineers who would be working out of their profession, so to speak?

MR. WARD: That, of course, is a very proper question. I don't know whether you read the New York Times. I don't know whether you have looked in the back pages of the Sunday edition and seen the innumerable solid pages advertising for engineers, including fishing, hunting, beautiful houses on lakes, ideal conditions to get postgraduate work in connection with their daily toil, wonderful sports facilities--skiing, golf--a Utopia. All you have to do is read that for the answer to your own question. There's no ~~surplus or shortage of jobs~~ over-supply now. There is a shortage.

Now, because we are a nation with free communications, several years ago Life Magazine, with its enormous circulation, published an article on, I believe, Wayne University, in Michigan; and I remember it well. It said that only 38 percent of the senior class of engineers were receiving employment; that there was an over-supply.

The preliminary of that article was submitted to certain leading educators, one of whom was the dean at Cornell, who was then the chairman of the

Society for the Promotion of Engineering Education and Accreditation Committee. He took one look at it and promptly blew up. It was based upon Bureau of Labor statistics, plus sampling Wayne University.

Now, gentlemen, I'm not running down Wayne University. It fulfills a fine need in its community. But it is not a national university. It is not a leader in engineering education. The day that they reported 38 percent getting jobs, Cornell had 68 percent that had jobs. And that's as high as you can go, because the rest won't take jobs because their parents are going to give them a vacation in Europe before they go to work.

That's like this statistic for unemployment, gentlemen. Don't get fooled by it. These are the fellows who left their jobs because they just plumb got tired and wanted to go to Florida or somewhere else. You can't hire those guys. There's a hard core of unemployables always. You have met some of them, I'll bet.

This is my answer, then, to your question: Life Magazine did not see fit to hold up that article and amend it. The dean showed them the error in the Bureau of Labor Statistics, pointed out the difference in experience in some of the leading colleges with the example they had selected, and their answer was: "Gee, whiz. It's already on the press." So it went out.

The next year, engineering freshmen dropped 11 percent in the United States, and the Bureau of Labor Statistics scrapped its statistical system and amended it in accordance with what the professor showed

to be the fact. The barn was locked, but the horse was out.

This is the way a free economy responds. The damage of that article is not yet completely rectified in the opinion of many people. This is why I said in answering the previous question that there has to be a more authoritative voice than Life Magazine, which I read with interest, to really tell the story. I think the American economy will then respond.

There was not an over-supply of engineers. And within one year after that article there was a drastic shortage.

Now, the worst of this, and my final comment on the problem, is that it is like a weapon system pipeline. What you do today you don't get the product of until four to five years later. You are feeling now what Life Magazine did to you four or five years ago. There's not a thing you can do about it. You cannot accelerate this period of gestation of engineers.

QUESTION: Mr. Ward, my question is somewhat along the line of Captain Masterson's but on a little different facet. Your lecture pointed out our deficiencies in pure and basic research, although one of your visual aids did show an encouraging increase in basic research. Can you suggest, sir, what means can be taken to improve the economic climate, that is, adequate pay, security, freedom of thought, so that more native-born Americans may be encouraged to undertake basic research?

MR. WARD: This means a change in public attitude in some ways.

but, more important than that, in the attitude of professors. When a student graduates as a baccalaureate, he goes to a professor of his choice and says, "I want to major in subject so-and-so. I'd like to study under you." And that professor then advises him.

Now, professors are human and they reflect this American attitude of putting the accent on people who do things rather than on people who think things. So I have to answer it very similar to the gentleman from the Department of the Interior. You have to change attitudes.

Now, this is a good time for me to tell what to me is one of the most striking examples of this attitude problem that you asked me about that I know of.

Russia, in taking over Hungary, found that its Parliament was falling into low repute. All of you know--I hope there are Hungarians in this audience--that they are a very intelligent people, with a long and fine history and fine universities. They're not serfs. And so when the Russian government found that the Hungarian Parliament was, as far as the people were concerned, in low repute, it said, "We have to tone itu up." So they decided to do so by picking a distinguished man and getting him to go into the Parliament. The man they picked was the senior professor of theoretical mathematics at the university. How many Americans would pick a senior mathematics professor to upgrade Congress?

Now, let's see what happened. After several years in Parliament he came to the conclusion that he was being used as a stooge. At the risk of his life and his family's life, he escaped from Hungary. He

could not find employment. He was in Germany at the time and decided that he would come to the land of opportunity, and he came to the United States.

He was employed by the University of Indiana at $6500 a year in their advanced mathematics department on the graduate level.

When Dr. Einstein was entering into the final years of his life, he was frantic to devise a single formula that included all of the known phenomena of physics. No one had ever incorporated the Maxwellian Laws into the general statement of the general theory of relativity. Each time he did this at the Princeton Institute for Advanced Studies, he or some other distinguished scientist would find that there was a flaw in his formula. He was becoming more frantic as he became older and wanted to die with this final accomplishment.

I think it was in 1953 that he produced the formula. But, gentlemen, he couldn't solve it. Nor could anyone else. One day the New York Times sent a science correspondent to the University of Indiana, having heard that this obscure gentleman from Hungary had solved the Einstein unsolvable equation. He had.

Now, gentlemen, think of a man with a mind able to solve the world's greatest mathematical statement, the author of which couldn't solve it, at $6500 a year, unknown, on a Mid Western college state campus.

Here you have my illustration. In Hungary he was big enough and important enough nationally to upgrade their Parliament. Here he

downgraded the professors.

I think you've got to convert the American people. I don't think you can order these things. I tried to get started in one of our leading universities an attack on the problem of the nature of force. No one in the world has defined a force. You deal with it in all of your work. It's the basis of combat warfare, it's the basis of engineering and science, and no one has explained force.

I have an apple and it drops. Newton said he could figure it, but he couldn't explain it. It'll drop in a vacuum just as well. What is the mechanism? What touches the apple? What accelerates the apple? The laws of momentum require that there be a force that accelerates it, and that force is like you when you throw it. What is that force? No one knows.

Now, here's one of the greatest unsolved phenomena of the universe. I got a president of a university, who was a social scientist, all steamed up on this. He saw a great challenge. I did it on the same basis that I talked to you gentlemen about here today--that this country had not recognized the role of the theoretician. He saw the challenge; so he agreed that he would back it.

The chairman of the Department of Physics backed it enthusiastically. He said: "I know of phenomena on forces that have never been even approaching an explanation. There are natural chemicals inert which can give birth just like a biological mechanism. By what force nobody knows." And he went into an area that he had been giving thought

to. He said: "If we can only start a basic research in this field, we don't know where it will lead."

So the first thing this gentleman did was to look all over the world. He found a man in Australia and another one in London who had been trying to work on this theory, and no one in this country. He went to the president of the university and me and he said, "We've got to bring these two men here." Everybody said, "Fine." They drew up a plan, took some office space, some desks, and a budget.

Do you know, we couldn't raise the money for that budget in the United States. It didn't make cakes of soap.

This is a deep-seated problem I am talking about. You gentlemen have it in your own establishment. I can't get a dime for some fundamental research on high temperature that may solve the high-energy fuel problem, because it is pure research and I can't prove what it'll do tomorrow.

Gentlemen, when you undertake pure research, basic research, you don't know what it's going to prove. So you can't write a specification and ask me to deliver something. I don't know what I'm going to deliver. But I know it's got to be done.

I'll bring an example right home to you in that one statement right there. You are about to maybe terminate the high-energy fuel program in Project B-70 because you put millions of dollars into an applied attempt to make the fuel and the research wasn't done. And now you've got those big monuments, about 90 million dollars of them, and you can't

make anything in them.

I don't know how to change the American point of view on these things, or yours in the services. You can get a hundred million dollars a darn sight easier than you can get a hundred thousand for pure research.

So I have to answer all of your questions, gentlemen, by saying that you, as citizens, have to get this concept in the United States of where our security lies. Where did it come from? Remember, now, there are darn few things that we made first in the United States, from four-wheel brakes to automobiles. They were made elsewhere.

CAPT. FIKE: Mr. Ward, your major purpose was to stimulate the interest of our students, and I am sure you have succeeded because we have more questions than time to permit answering them. I am afraid we are going to have to bring this to a close. On behalf of the Commandant and the students, I want to thank you very much for a most stimulating and very comprehensive discussion.

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